IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS:	Dai et al.
DOCKET NO.:	1297
SERIAL NO.:	10/770,734
CONFIRMATION NO.:	9998
FILED:	February 3, 2004
ART UNIT:	1793
EXAMINER:	Stuart L. Hendrickson
TITLE:	**Robust Carbon Monolith Having Hierarchical Porosity**

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
Mail Stop Non-Fee Amendment
P.O. Box 1450
Alexandria, VA 22313-1450

I, **Chengdu Liang**, hereby declare that:

1. I am a co-inventor of the above-referenced application.

2. I earned and was granted a PhD. in Chemistry from the University of Tennessee in Knoxville, Tennessee in May 2005.

3. I am currently employed as a staff scientist at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, by UT-Battelle, LLC, the assignee of the above-identified application.

4. I am recognized as an expert in the field of nanophase materials sciences, as evidenced by my curriculum vitae, which also includes a listing of my publications. My

curriculum vitae is appended hereto as Appendix A.

4. I have read and understood the contents of the above-identified patent application, the examiner's rejection of claim 1-10 over Taguchi et al. (*Adv. Mater.*, 2003, 15:1209-1211) as set forth in the office action dated November 28, 2007.

5. Figure 3 of Taguchi et al. discloses a TEM image of a porous carbon monolith with a 200 nm scale bar.

6. The formula for calculating magnification is well known to those of ordinary skill in the art. See for example the book titled Biology for OCR, published by the Cambridge University Press, 2008. Page 2 of Biology for OCR, attached as Appendix B, provides the formula for calculating magnification as follows:

$$\text{Magnification} = \frac{\text{Size of image}}{\text{Real size of object}}$$

7. The size of the bar in figure 3 of Taguchi et al. has a length of 1.0 cm. The real size of the bar scale is listed in figure 3 of Taguchi et al. as being 200 nm. Therefore, the magnification utilized in figure 3 is calculated as follows:

$$\text{Magnification} = \frac{1 \text{ cm}}{200 \times 10^{-7} \text{ cm}} = 50{,}000$$

8. Therefore, figure 3 of Taguchi et al. is magnified 50,000 times.

9. Similarly, the magnification of figure 16 of the above-identified application can be calculated. The size of the bar in figure 16 of the application is 4.2 cm. The real size of the bar scale is listed in figure 16 as being 80 nm. Therefore, the magnification utilized in figure 16 is calculated as follows:

$$\text{Magnification} = \frac{4.2\ \text{cm}}{80 \times 10^{-7}\ \text{cm}} = 525{,}000$$

10. Therefore figure 16 of the above-referenced application is magnified 525,000 times.

11. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

Chengdu Liang

Chengdu Liang

Feb. 12, 2008

Date

APPENDIX A

Chengdu Liang

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Education

Doctor of Philosophy: May 2005
University of Tennessee, Knoxville
Major: chemistry concentrated on inorganic & *analytical chemistry*
(Research advisors: Dr. Georges Guiochon and Dr. Sheng Dai)

Master of Science: June 1998
Xiangtan University, P. R. China
Major: chemistry concentrated on *organic chemistry*

Bachelor of Science: June 1995
Xiangtan University, P. R. China
Major: chemistry concentrated on *organic chemistry*
Minor: *computer science*

Honors and Achievements

- 2002 to 2005: TAML fellowship awarded by ORNL/UTK through distinguished scientist program and funded by NSF through a competition based on research achievements
- 2004: Chemistry Department Research Merit Award, UTK
- 2003: Chemistry Department Merit award, UTK
- 1998: Merit Graduate Student Award, Xiangtan University
- 1995: Thesis Award, Xiangtan University
- 1994: Merit Award of Undergraduate Student, Xiangtan University

Experiences

Staff scientist: Oct. 2006 to present
Joint appointment by Center for Nanophase Materials Sciences and Chemical Sciences Division Oak Ridge National Laboratory
Work on synthesis, modification, and characterization of nanostructured carbon materials, organic/inorganic hybrid materials, nanocatalysts and nanobuilding blocks for energy storage, conversion, energy related separations, and alternative energy sources.

Coordinate user projects for the catalysis and nanobuilding block theme area. Recruit, review, serve, and guide user projects. Supervise on-site user activities. Mentor interns at undergraduate and graduate levels.

Postdoctoral research fellow: May 2005 to Oct. 2006

Oak Ridge national Laboratory

Work on the synthesis and characterization of novel nanophase materials for energy storage and chemical separations.

Tennessee Advanced Material Laboratory (TAML) fellowship and research associate: 2002 to May 2005

Oak Ridge National Laboratory (ORNL)/ the University of Tennessee, Knoxville (UTK)

Worked with two groups one at ORNL and one at UTK with expertise in synthesis of adsorbents and HPLC technologies, respectively. My research covered four aspects:

1) synthesis of monolithic media: silica, carbon, and polymer-based monoliths
2) morphological synthesis and porosity control: synthesis of mesoporous silica using surfactants as pore forming agents, particle shape and size control based on sol-gel chemistry, and tailored synthesis of hierarchically porous carbon
3) surface modification of adsorbents: grafting organic functionalities on sol-gel glasses, electrochemical modification of carbon adsorbents, and molecular imprinting on polymer surfaces
4) Structural characterization of inorganic and hybrid nanomaterials.
5) column technologies and LC instrumentation: encasing monolithic media, novel configuration of electrochemically modulated liquid chromatography, and electrochemically modulated thin layer liquid chromatography.

Visiting scholar: 2000 to 2001

Department of chemistry, University of Tennessee Knoxville

Research on implementation of sol-gel chemistry in organic/inorganic hydride materials, surface modification of sol-gel glasses, synthesis and analytical application of molecularly imprinted sol-gel adsorbents, and silica media for HPLC column.

Research staff: 1998 to 2000

Material research division, Zhuzhou Institute of Technology, P.R. China

Primarily involved in the synthesis of molecularly imprinted polymer (MIP) thin films for the selective absorption of biomolecules

Graduate teaching assistant: 1995 to 1998

Department of chemistry, Xiangtan University, P.R. China
Teaching organic chemistry and organic chemistry lab for three years and about 20 hours in each semester

Field consultant: 1994 to 1997
Zhejiang Linhai City Pharmaceutical Company
Providing field services and consulting on the synthesis of pyridone carboxylic acid based antibacterial agents.

Techniques

- Proficient in synthesis and characterization of nanostructured materials
- Intensively trained in inorganic synthesis with rich experiences in nonaqueous synthetic techniques and the manipulation of air sensitive materials
- Skilled in HPLC, TLC, GC, FTIR, SEM, TEM, Raman, and small & wide angle X-ray diffraction
- Experienced in BET measurement for the analysis of pore size and surface area, light scattering measurement for particle sizing, thermal gravimetric analysis (TGA).

Research Achievements and Academic Activities

- 2 US patents for separation media
- 34 publications and 3 book chapters
- 10 presentations in academic conferences
- 1 invited talk in America Chemical Society National Meeting
- 1 invited talk in separation industry
- 4 years volunteer work in PREP conferences
- 1 years volunteer work in HPLC conferences
- 11 research projects
- Over 300 citations

Publications and Academic Activities

Publications:

1. Chen, B., Ma, S.Q., Hurtado, E.J., Lobkovsky, E.B., Liang C.D., Zhu, H.G., Dai, S., Selective Gas Sorption within a Dynamic Metal-Organic Framework, **Inorganic Chemistry**, 2007 (in press)
2. Ma, Z., Liang, C.D., Overbury, S.H., Dai, S., Gold nanoparticles on electroless-deposition-derived MnO_x/C: synthesis, characterization, and catalytic CO oxidation, **Joaurnal of Catalysis**, 2007 (in press)
3. Larsen, PV., Liang, CD., Maje, W., Dai, S., Yan YS., Graphitic Mesoporous Carbon as a Durable Fuel Cell Catalyst Support **Journal of the American Chemical Society,** 2007 (submitted)
4. Liang, CD., Li, Z., Dai, S., Mesoporous Carbon Materials: Synthesis and Modification **Angew. Chem. International Edition,** 2007 (in press)
5. Gierszal, K.P., Jaroniec, M., Liang, C.D., and Dai, S. Electron microscopy and nitrogen adsorption studies of film-type carbon replicas with large pore volume synthesized by using colloidal silica and SBA-15 as templates **Carbon** 2007, 45, 2171
6. Steinhart, M., Liang, C.D., Lynn, G.W., Gösele, U., Dai S., Direct Synthesis of Mesoporous Carbon Microwires and Nanowires **Chemistry of Materials**, 2007, 19, 2383
7. Hou, CH., Liang, CD, Yiacoumi, S., Dai, S., Tsouris, C., Electrosorption Capacitance of Nanostructured Carbon-based Materials **Journal of Colloid and Interface Science** 2006, 302 (1): 54-61
8. Zhu, H., Liang, CD, Yan, W., Overbury, S. H., Dai, S, Preparation of Highly Active Silica-Supported Au Catalysts for CO Oxidation by a Solution-Based Technique **J. Phys. Chem. B.** 2006, 110, 10842
9. Liang CD, Dai S, Synthesis of Mesoporous Carbon Materials via Enhanced Hydrogen-bonding Interaction **Journal of the American Chemical Society,** 2006, 128, 5316
10. Chen BL, Liang CD, Yang J, Contreras DS, Clancy YL, Lobkovsky EB, Yaghi OM, Dai S, *A Microporous metal-organic framework for gas chromatographic separation of alkanes* **Angew. Chem. International Edition,** 2006, 45, 1390-1393
11. Liang CD, Huang JF, Luo HM, Li ZJ, Dai S, *A Diazonium Salt-Based Ionic Liquid for Solvent-Free Modification of Carbon* **Eur. J. Org. Chem,** 2006, 586-589
12. Mahurin, S, Bao, LL, Yan, WF, Liang, CD, Dai, S., Atomic layer deposition of TiO2 on mesoporous silica, **Journal of Non-crystalline Solids** 2006, 352, 3280-3284
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high proton conductivity and blue photoluminescence **Journal of the American Chemical Society,** 2005, 127 (37): 12784
14. Zhu HG, Pan ZW, Hagaman EW., Liang CD, Overbury SH. and Dai ; *Facile one-pot synthesis of gold nanoparticles stabilized with bifunctional amino/siloxy ligands* **Journal of Colloid and Interface Science** 2005,287,360-365.
15. Liang CD, Hong KL, Mays J, Guiochon G; Dai S; *Synthesis of Large-scale Highly Ordered Porous Carbon Film via Self-assembly of Block Copolymers;* **Angew. Chem. International Edition,** 2004, 5785-5789.
16. Li ZJ, Del Cul GD, Yan WF, Liang CD, and Dai S; *Fluorinated carbon with ordered mesoporous structure;* Journal of the American Chemical Society 2004, 126 (40): 12782-12783.
17. Liang CD, Dai S, and Guiochon G; *A graphitized-carbon monolithic column*; **Analytical Chemistry**, 2003, 75 (18): 4904-4912.
18. Bao LL, Mahurin M. S, Liang CD, and Dai S; *Study of Silver Films over Silica Beads as a Surface Enhanced Raman Scattering (SERS) Substrate for Detection of Benzoic Acid* **Journal of Raman Spectroscopy**, 2003,34,394-398.
19. Liang CD, Yuan CY, Warmack RJ, Barnes CE, Dai S; *Ionic liquids: A new class of sensing materials for detection of organic vapors based on the use of a quartz crystal microbalance* **Analytical Chemistry** 74 (9): 2172-2176 MAY 1 2002.
20. Liang CD, Dai S, Guiochon G; *Use of gel-casting to prepare HPLC monolithic silica columns with uniform mesopores and tunable macrochannels* **Chemical Communications** (22): 2680-2681 NOV 21 2002.
21. Liang CD, Weaver MJ, Dai S; *Change of pH indicator's pK(a) value via molecular imprinting* **Chemical Communications** (15): 1620-1621 2002.
22. Tan YG, Yin J, Liang CD, Peng H, Nie LH, Yao SZ, *A study of a new TSM bio-mimetic sensor using a molecularly imprinted polymer coating and its application for the determination of nicotine in human serum and urine*, **Bioelectrochemistry,** 2001, 53 (2), 141-148.
23. Tan YG, Peng H, Liang CD, Nie LH, Yao SZ, *A new assay system for phenacetin using biomimic bulk acoustic wave sensor with a molecularly imprinted polymer coating*, **Sensors and actuators B: Chemistry**, 2001, 73 (2-3), 179-184.
24. Peng H, Liang CD, Zhou AH, Zhang YL, Xie QJ, Yao SZ, *Development of a new atropine sulfate bulk acoustic wave sensor based on a molecularly imprinted electrosynthesized copolymer of aniline with o-phenylenediamine*, **Analytica Chimica Acta,** 2000, 423 (2), 221-228.
25. Peng H, Liang CD, He DL, Nie LH, Yao SZ, *Bulk acoustic wave sensor using molecularly imprinted polymers as recognition elements for the determination of pyrimethamine*, **Talanta,** 2000, 52 (3), 441-448.
26. Peng H, Liang CD, He DL, Nie LH, Yao SZ, *Non-aqueous assay system for phenobarbital using biomimetic bulk acoustic wave sensor*

based on a molecularly imprinted polymer, **Analytical letters**, 2000, 33(5), 793-808.

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29. Liang CD, Peng H, Nie L, and Yao S, *Bulk acoustic wave sensor for herbicide assay based on molecularly imprinted polymer;* **Freseniu's Journal of Analytical Chemistry**, 2000, 376(6), 551-555
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31. Liang CD, Lin YB, and Liu ZC, *Study of the synthesis of piper acid by air-oxidation*, **Xiangtan Daxue Xuebao** 1999, 21(2), 59-61 (in Chinese)
32. Liang CD, Lin YB, and Liu ZC, *Novel synthetic method of thiophenine*, **Xiangtan Daxue Xuebao** 1998, 20(4), 60-62 (in Chinese)
33. Liang CD, Lin YB, and Liu ZC, *Virtual reality modeling language and development of the molecular graph maker system*, **Computerized and Applied Chemistry**, 1997, 14(4), 317-319 (in Chinese)
34. Liu ZC, Lin YB, and Liang CD, *Preparation of copper phthalocyanin in solution of methyldiphenlymethane*, **Dye Industry**, 1997, 5, 16-17 (in Chinese).

Book Chapters:

Sheng Dai, Zongtao Zhang, and Chengdu Liang, (2004) "Hierarchically Imprinted Nanostructures for Separation of Metal Ions". In "**Dekker Encyclopedia of Nanoscience and Nanotechnology**", Marcel Dekker, Inc., New York, Edited by James A. Schwarz, Cristian I. Contescu and Karol Putyera. 1369-1376

Hyunjung Kim, Chengdu Liang, and Sheng Dai (in press) "Chapter 9 Hierarchically Imprinted Adsorbents". In "**Environmental Applications of Nanomaterials**" World Scientific Publishing Co Pte Ltd., edited by G. E. Fryxell and B. Cao.

Xiqing Wang, Chengdu Liang, and Sheng Dai "Nano/microporous materials: mesoporous and surface-functionalized mesoporous carbon". In "**2nd Edition of the Encyclopedia of Inorganic Chemistry (EIC)**" John Wiley & Sons, Ltd (In press)

Patents:

1. Dai S, Guiochon G, and Liang CD, *Robust Carbon Monolith Having Hierarchical Porosity*; US patent filed on Feb 3, 2004.
2. Dai S, Liang CD, *Synthesis and Applications of Ordered Mesoporous Carbon*; US patent filed on Sep 28, 2004.

Presentations:

1. *Investigation of Graphitized Mesoporous Carbon Materials as Supports for Fuel-Cell Electrocatalysts.* **Southeastern Catalyst Society 2006 Annual Conference** Asheville, NC, Oct. 2006
2. *Pore engineering and surface modification of monolithic carbon columns.* **Pittcon 2006**, Orlando, FL, Mar 2006
3. *Synthesis and modification of monolithic* ***carbon*** *columns.* **Pittcon 2005**, Orlando, FL, Feb 2005
4. *Ultra-fast separation based on carbon monolithic columns.* **HPLC 2004** Philadelphia, PA, Jun 2004
5. *Hierarchically porous carbon monolithic column.* **Pittcon 2004** Chicago, IL USA, Mar 2004
6. *Synthesis and Characterization of Monolithic Column Materials with Tailored Hierarchical Porous Structure.* **Tennessee Advance material Laboratory (TAML)** Knoxville, TN, Aug 2004
7. *Ionic liquids: A new class of sensing materials for detection of organic vapor based on quartz crystal microbalance.* **222nd The American Chemical Society Meeting**, Chicago, IL USA, August 2001
8. *Room-Temperature Ionic Liquids for Synthesis of Advanced Materials.* **6th International symposium on molten salt chemistry and technology**, Shanghai, China. Oct. 2001
9. *Synthesis and characterization of molecularly imprinted electrocopolymers by combined quartz crystal impedance and electrochemical impedance measurement.* **MIP2000: 1st International Workshop on Molecularly Imprinted Polymers**, Cardiff, England. July 2000

Invited Talk:

1. *Investigation of Functionalized Mesoporous Carbons as Heterogeneous Catalyst for Biodiesel Production.* **American Chemical Society National Meeting Chicago**, IL, Mar. 2007
2. *Monolithic carbon columns and related techniques*, **Waters Corporation** Milford, MA 2004 October

Academic Activities:

- 4 years Volunteer work on 15th to 18th International Symposium, Exhibit, and Workshops on Preparative / Process Chromatography (**PREP symposium 2002 to 2005**)
- Volunteer work on 28th International Symposium on High Performance Liquid Phase Separations and Related Techniques (**HPLC 2004**)

Research Projects:

1. **Novel nanostructured materials for new catalysts and catalysis research,** Co-PI, awarded by US Department of Energy
2. **Fundamental studies of novel separations,** Co-PI, awarded by US Department of Energy
3. **Highly ordered nanoporous carbon materials via self-assembly of block copolymers,** awarded CNMS user proposal
4. **Novel Carbon Materials for Advanced Energy Storage,** funded by a LDRD project at ORNL
5. **Basic energy science program on separation,** funded by US Department of Energy
6. **Molecular imprinting in sol gel glasses,** funded by US Department of Energy EMSP Program
7. **Synthesis of novel environment-friendly packaging polymers,** funded by National Science Foundation of China Branch of Hunan Province, Principal Investigator of the project
8. **Molecular imprinting technique and its applications in life science and environmental chemical analysis,** funded by the National Nature Science Foundation of China
9. **The fundamental research of chemical and bio-chemical sensors,** Key project supported by the National Nature Science Foundation of China
10. **Theoretical and practical study of organic functional materials,** funded by National Science Foundation of China Branch of Hunan Province
11. **Synthesis of the intermediate compounds of pyridone carboxylic acid based antibacterial agents,** funded by Zhejiang Linhai City Pharmaceutical Company

APPENDIX B

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More information

Biology 1 FOR OCR

Mary Jones

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Chapter 1

Cell structure

Background

e-Learning

All living organisms are made of cells. Cells are the basic units of living things, and most scientists would agree that anything that is *not* made of a cell or cells – for example, a virus – cannot be a living organism.

Some organisms, such as bacteria, have only one cell, and are said to be **unicellular**. Others have millions of cells. Any organism that is made up of more than one cell is said to be **multicellular**.

All cells are very small, but some of them are just large enough to be seen with the naked eye. The unicellular organism *Amoeba*, for example, can just be seen as a tiny white speck floating in liquid if you shake up a culture of them inside a glass vessel. These cells are about 0.1 mm across. However, this is unusually large. Human cells are usually somewhere between 10 µm and 30 µm in diameter (see the box on page 3 for an explanation of 'µm'). Bacterial cells are much smaller, often about 0.5 µm across. To see most cells, a microscope must be used.

Microscopes

The first microscopes were invented in the mid 17th century. They opened up a whole new world for biologists to study. Now biologists would see tiny, unicellular organisms whose existence had previously only been guessed at. They could also see, for the first time, that large organisms such as plants and animals are made up of cells.

Light microscopes

The early microscopes, like the microscopes that you will use in the laboratory, were **light microscopes**. Light microscopes use glass lenses to refract (bend) light rays and produce a magnified image of an object. Figure 1.1 shows how a light microscope works.

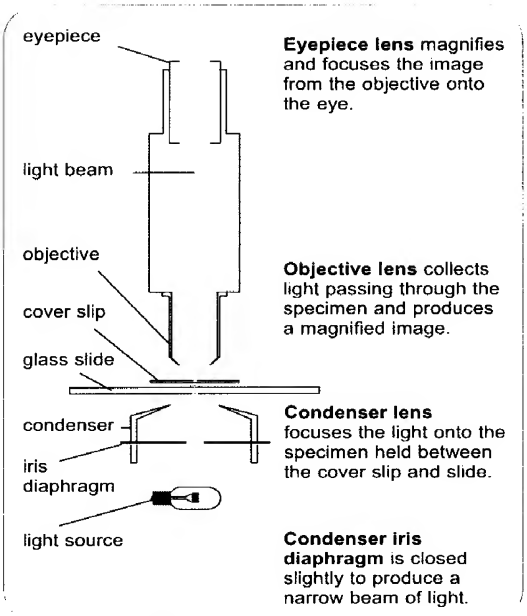

Figure 1.1 How a light microscope works.

The specimen to be observed usually needs to be very thin, and also transparent. To keep it flat, it is usually placed on a glass slide with a very thin glass coverslip on top. For a temporary slide, you can mount the specimen in a drop of water. To make a permanent slide, a liquid that solidifies to produce a clear solid is used to mount the specimen.

The slide is placed on a stage through which light shines from beneath. The light is focused onto the specimen using a **condenser lens**. The light then passes through the specimen and is captured and refracted by an **objective lens**. Most microscopes have three or four different objective lenses, which provide different fields of view and different magnifications. The greater the magnification, the smaller the field of view.

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The light rays now travel up to the **eyepiece lens**. This produces the final image, which falls onto the retina of your eye. The image can also be captured using a digital camera or video camera, and viewed or projected onto a screen.

Many biological specimens are colourless when they have been cut into very thin sections, so a **stain** is often added to make structures within the specimen easier to see (Table 1.1). Different parts of a cell, or different kinds of cells, may take up (absorb) a stain more than others. For example, a stain called methylene blue is taken up more by nuclei than by cytoplasm, so it makes a nucleus look dark blue while the cytoplasm is pale blue. Methylene blue is taken up by living cells, but many other stains cannot get through the cell membrane of a living cell and can only be used on dead cells.

Magnification

Using a microscope, or even just a hand lens, we can see biological objects looking much larger than they really are. The object is **magnified**. We can define magnification as the size of the image divided by the real size of the object.

$$\text{magnification} = \frac{\text{size of image}}{\text{real size of object}}$$

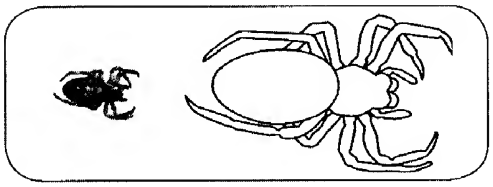
For example, we can calculate the magnification of the drawing of a spider in Worked example 1.

Worked example 1

Calculation of the magnification of a drawing.

$$\text{magnification} = \frac{\text{size of image}}{\text{real size of object}}$$

Below is a 'real' spider and a drawing of this spider.



Step 1 Measure the length of the 'real' spider. You should find that it is 10 mm long. The length of the spider in the drawing is 30 mm.

Step 2 Now, substitute these numbers into the equation above:

$$\text{magnification} = \frac{30}{10} = \times 3$$

Notice the '×' sign in front of the number 3. This stands for 'times'. We say that the magnification is 'times 3'.

Stain	Use	Colours produced
methylene blue	staining living cells	dark blue nucleus, light blue cytoplasm (in bacteria, the whole cell takes up the stain)
iodine solution	staining living plant cells	very dark blue starch grains
acidified phloroglucinol	staining lignin (the substance in the cell walls of xylem vessels)	bright red
acetic orcein	staining nuclei and chromosomes	red
eosin	staining cytoplasm and some organelles (it stains dead cells only and so can be used to distinguish between live and dead sperm cells)	pink
light green	staining plant cell walls	green

Table 1.1 Some stains commonly used in light microscopy.

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SAQ

1 A person makes a drawing of an incisor tooth. The width of the actual tooth is 5 mm. The width of the tooth in the drawing is 12 mm.
Calculate the magnification of the drawing.

Hint

Answer

Units of measurement

In biology, we often need to measure very small objects. When measuring cells or parts of cells, the most common (and useful) unit is the **micrometre**, written **µm** for short. The symbol µ is the Greek letter mu. One micrometre is one thousandth of a millimetre.

Even smaller structures, such as the organelles within cells, are measured using even smaller units. These are **nanometres**, written **nm** for short. One nanometre is one thousandth of a micrometre.

$$1\,\mu m = \frac{1}{1000}\ mm$$

This can also be written 1×10^{-3} mm, or 1×10^{-6} m.

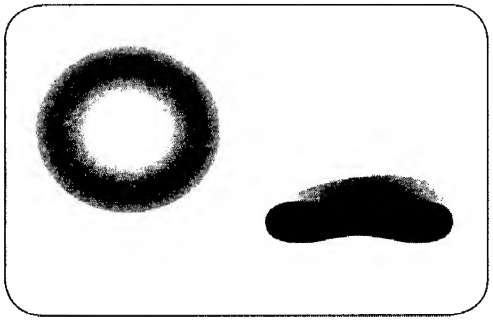
$$1\,nm = \frac{1}{1000}\ \mu m$$

This can also be written 1×10^{-6} mm, or 1×10^{-9} m.

Often, we are dealing with small units, such as µm. It is important to make sure all your measurements are in the same units. It is often best to convert everything into µm before you begin your calculation, as shown in Worked example 2.

Worked example 2

Calculation of magnification and conversion of units.



Let us say that we know that the real diameter of a red blood cell is 7 µm and we have been asked to calculate the magnification of the above diagram.

Step 1 Measure the diameter of the cell in the diagram. You should find that it is 30 mm.

Step 2 We have been given its real size in µm, so we need to convert the 30 mm to µm. There are 1000 µm in 1 mm, so 30 mm is 30×1000 µm.

Step 3 Now we can put the numbers into the equation:

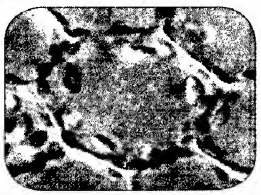
$$\text{magnification} = \frac{\text{size of image}}{\text{real size of object}}$$

$$= \frac{30 \times 1000}{7}$$

$$= \times 4286$$

SAQ

2 This is a **photomicrograph** – a photograph taken using a light microscope. The actual maximum diameter of the cell is 50 µm. Calculate the magnification of the photomicrograph.



Hint

Answer

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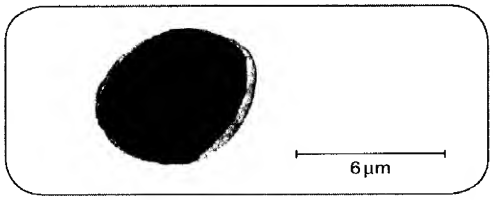
Worked example 3

Calculating magnification from a scale bar.

This diagram shows a lymphocyte.



We can calculate the magnification of the image of the lymphocyte without needing to measure it or to know anything about its original size. We can simply use the **scale bar**. All you need to do is to measure the length of the scale bar and then substitute its measured length and the length that it represents into the equation. (Remember to convert your measurement to µm.)

Step 1 Measure the scale bar. Here, it is 24 mm.

Step 2 Substitute into the equation.

$$\text{magnification} = \frac{\text{size of image}}{\text{real size of object}}$$

$$\text{magnification} = \frac{\text{the length of the scale bar}}{\text{the length the scale bar represents}}$$

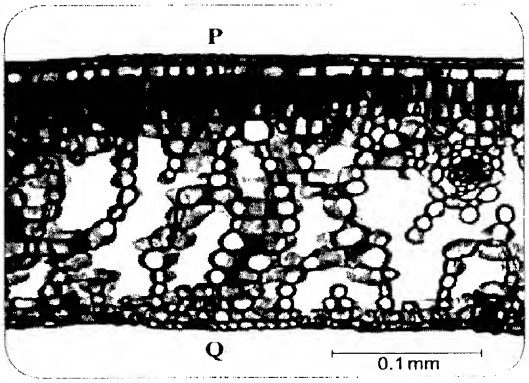
$$= \frac{24 \times 1000\,\mu\text{m}}{6\,\mu\text{m}}$$

$$= \times 4000$$

SAQ

3 This is a photomicrograph of a transverse section through a leaf. Use the scale bar to calculate the magnification of the photomicrograph.

Hint



Answer

4 If we know the magnification, we can turn the equation around so that we can calculate the real size of something from its magnified image.

Hint

$$\text{real size of object} = \frac{\text{size of image}}{\text{magnification}}$$

Use your value for the magnification of the photomicrograph above to calculate the thickness of the leaf between P and Q.

Answer